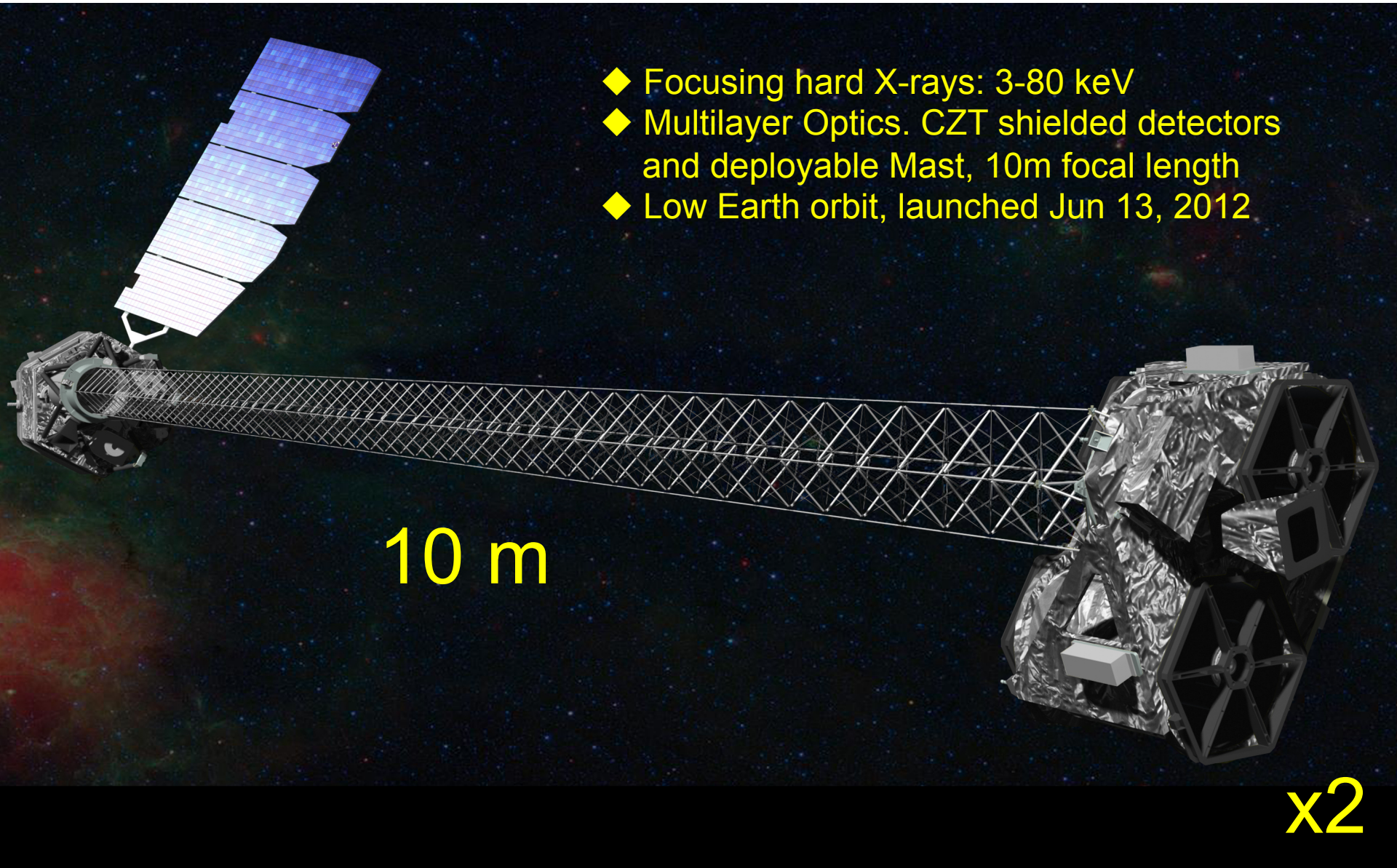
Памяти Михаила Ревнивцева

Рентгеновское излучение от Галактического Центра на малых и больших масштабах по данным телескопа НуСТАР

Роман Кривонос (ИКИ РАН)

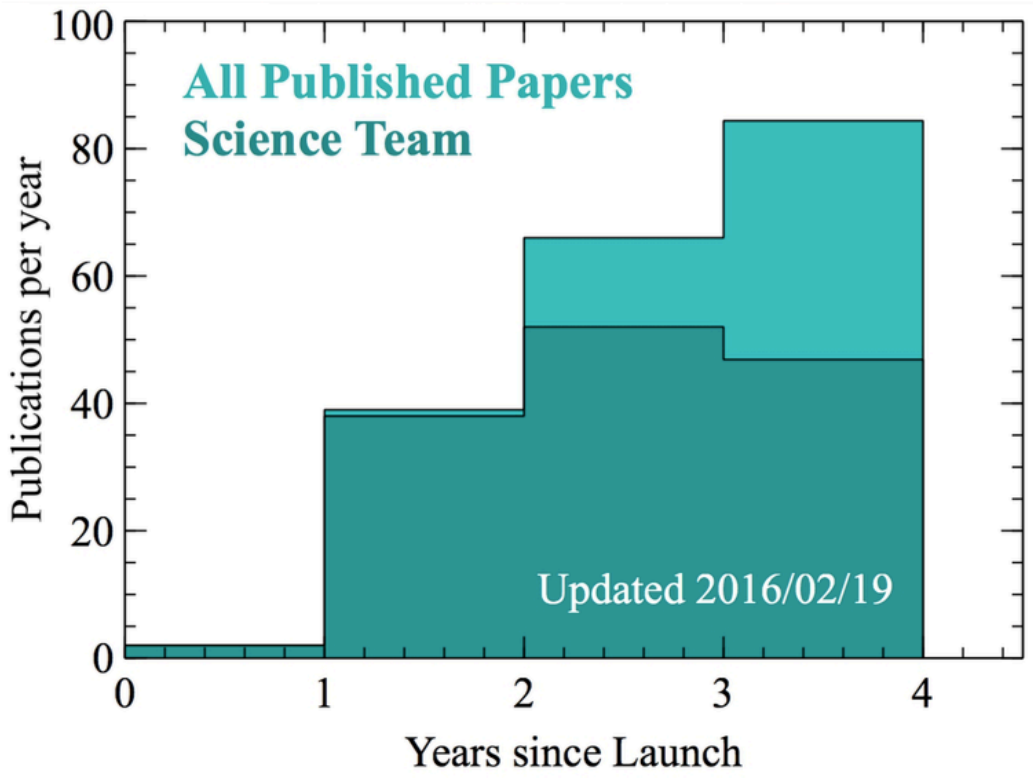
HEA-2016

NuSTAR
an Explorer Class Mission



- Focusing hard X-rays: 3-80 keV
- Multilayer Optics. CZT shielded detectors and deployable Mast, 10m focal length
- Low Earth orbit, launched Jun 13, 2012

x2

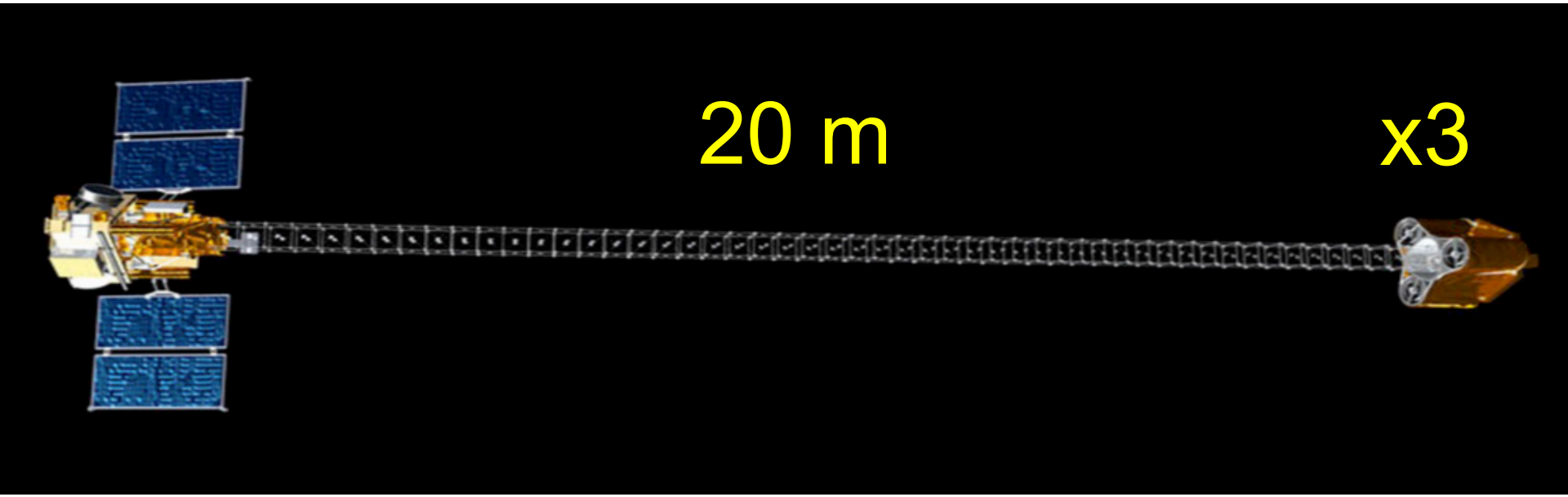


- >220 papers published

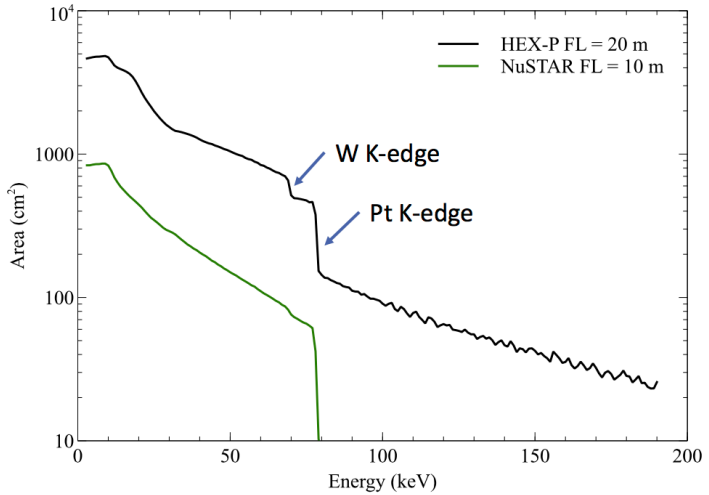
Projected 10 year lifetime

AO-3 Proposals are due on January 27, 2017

HEX-P Design



Similar to ART-XC

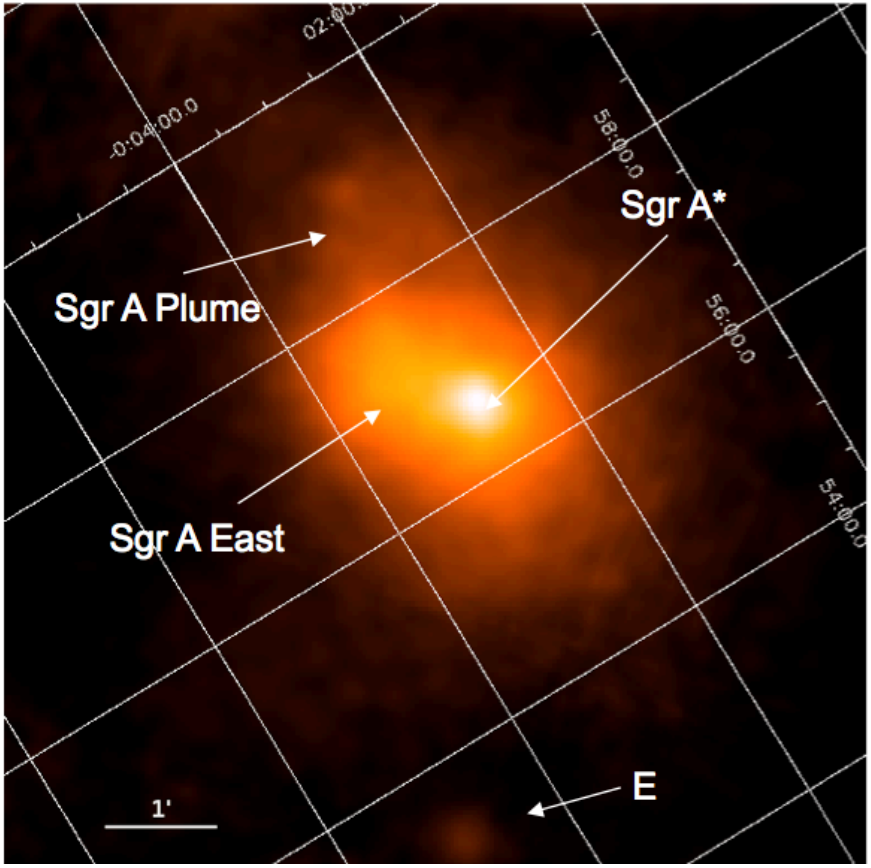


Outline of the talk

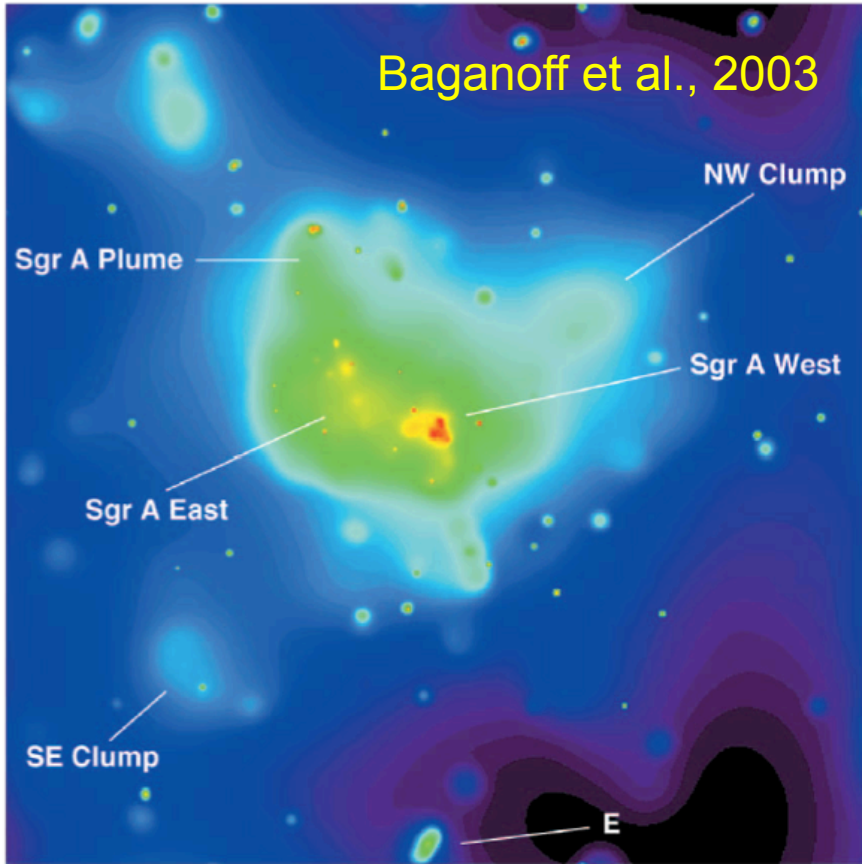
- Inner ~10 pc: Discovery of central hard X-ray population
- Inner ~100 pc: NuSTAR point source survey
- Inner ~kpc: Broad-band X-ray emission along the Galactic Ridge

NuSTAR morphology of GC is similar to Chandra

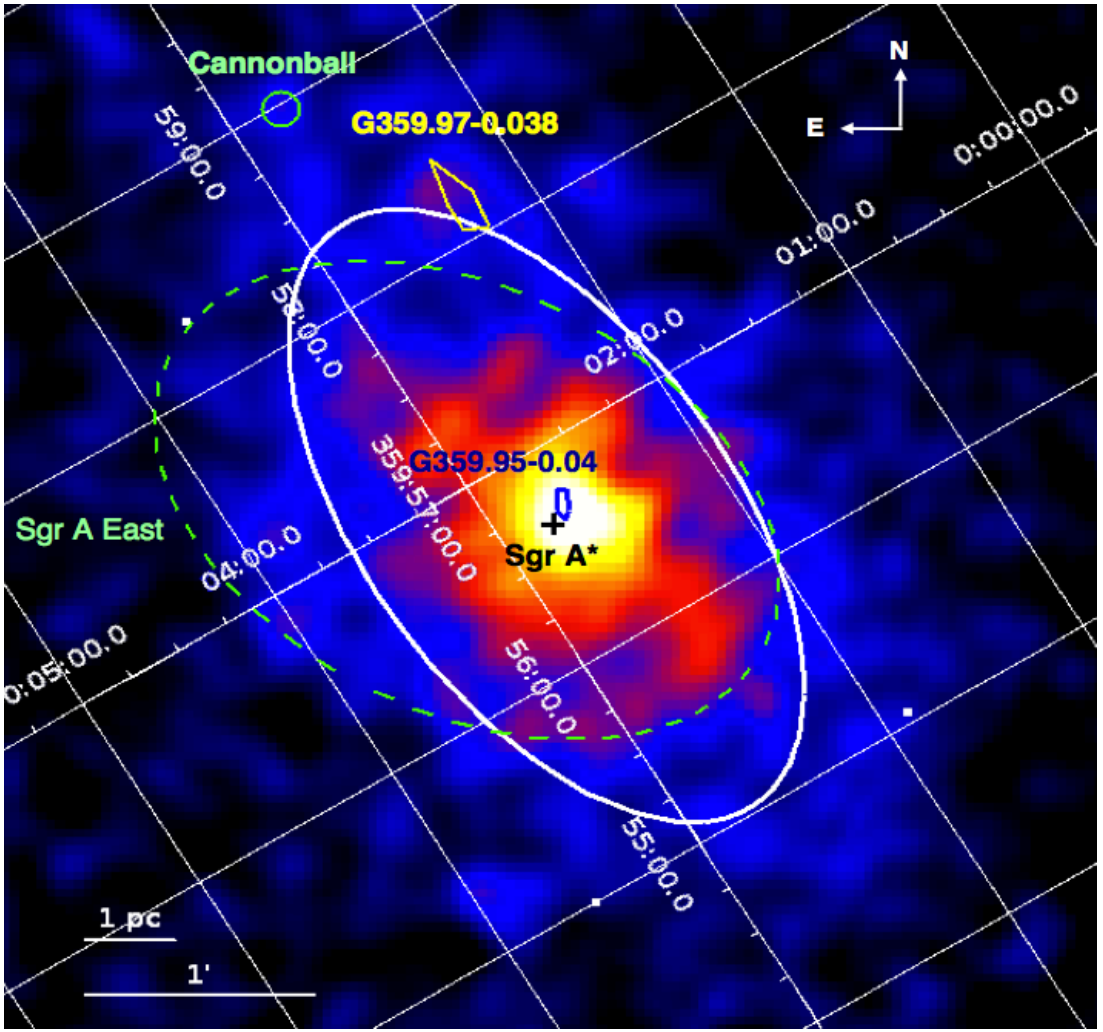
NuSTAR 3-79 keV



Chandra 2-10 keV



Sgr A extended emission*
Perez et al., 2015, Nature

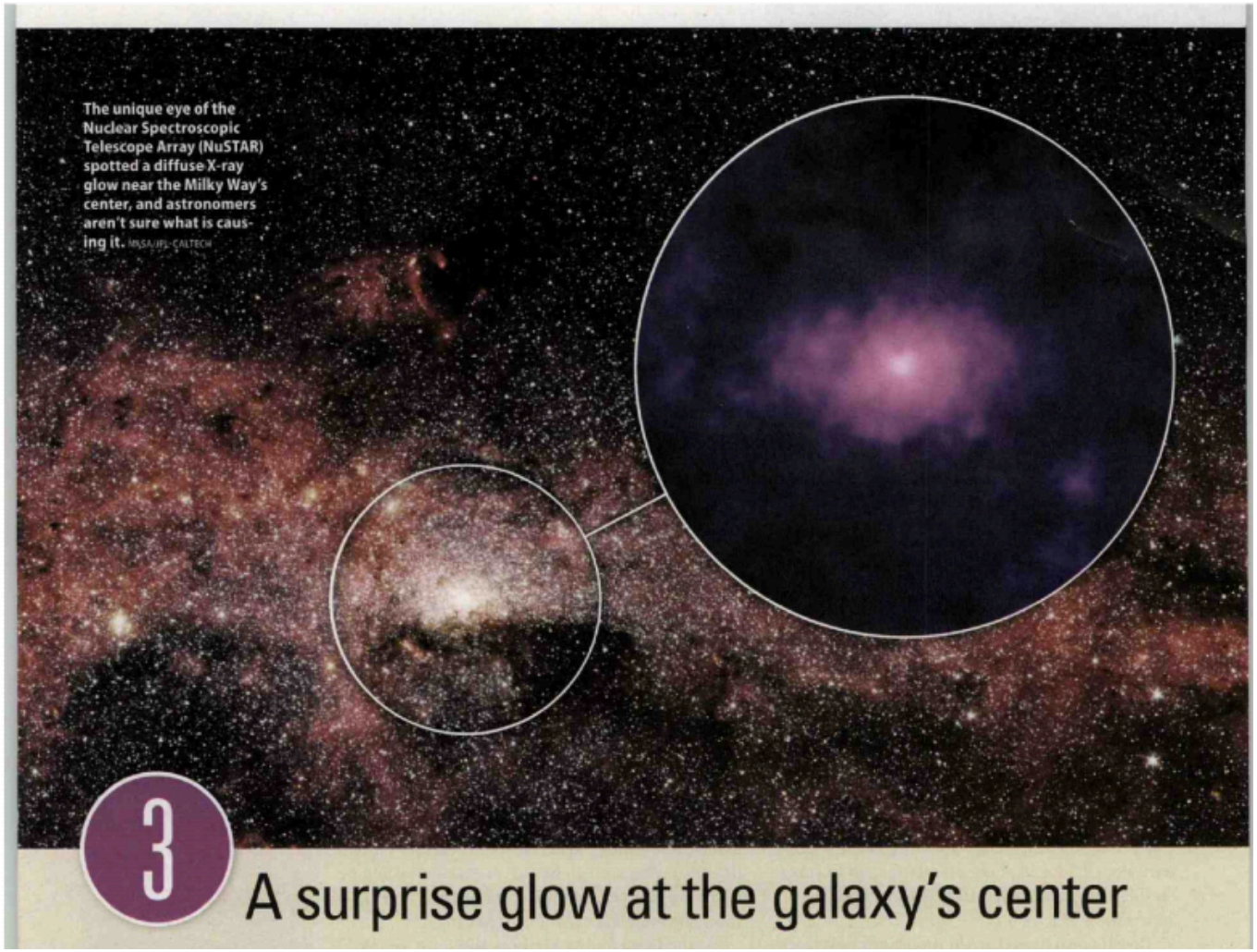


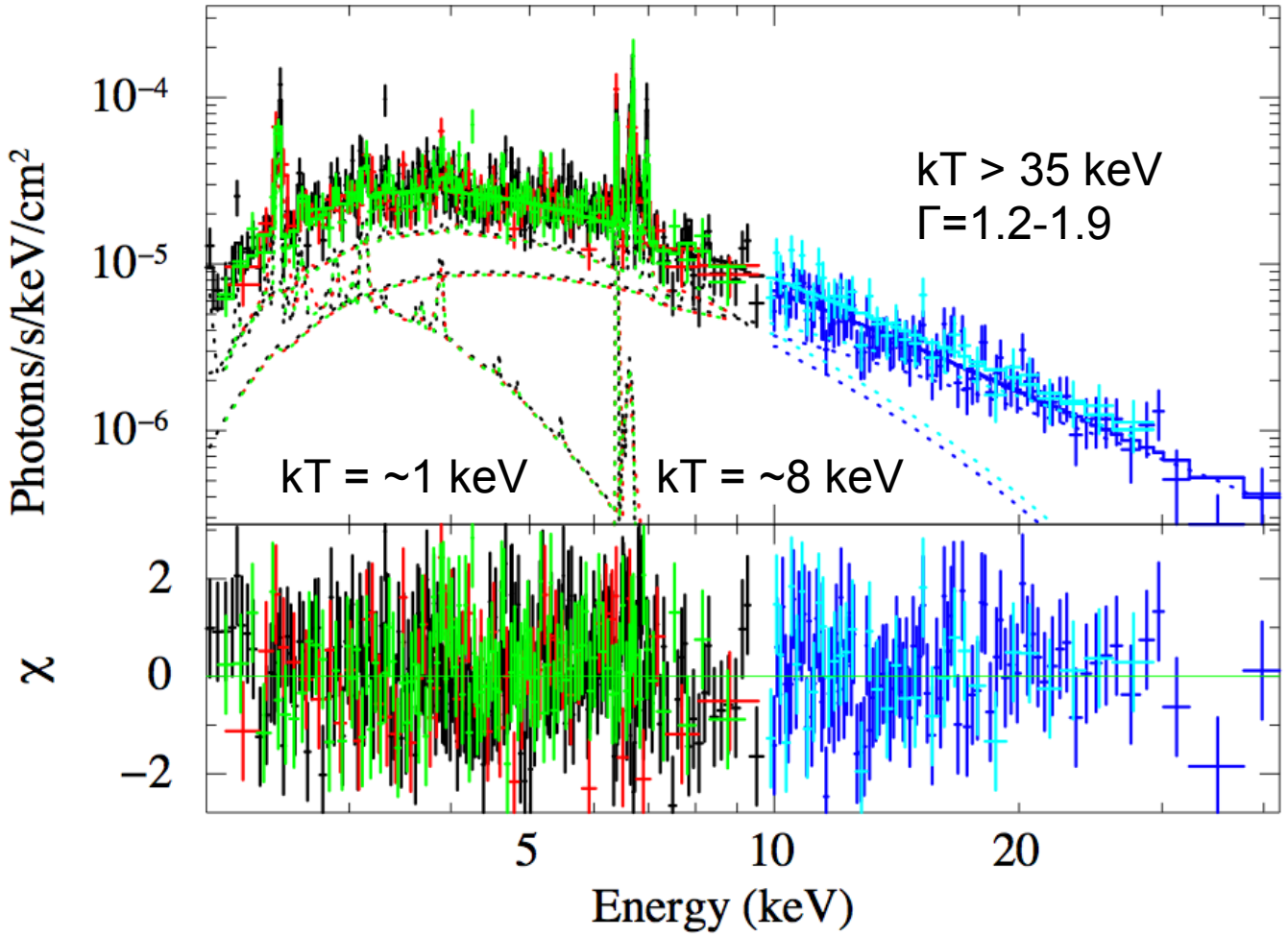
12 pc

L(20-40 keV)=
2.4e34 erg/s
in 4pc x 8pc

1e3-1e4 hot IPs

Astronomy Magazine top 10 discoveries in 2015



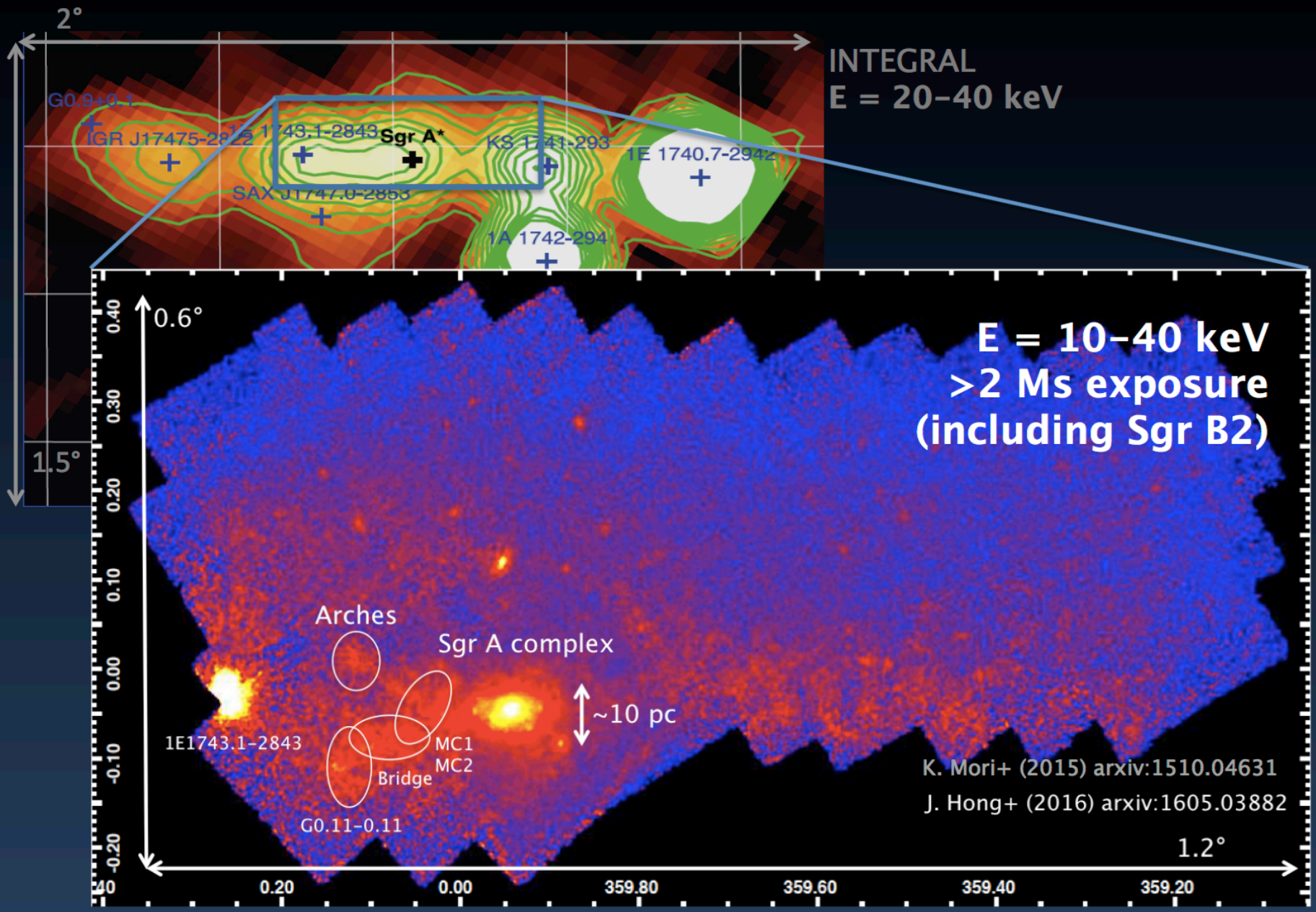


- the same spectrum for another wing
- L(2-10 keV)/M=9e27 srg/s/Msun – consistent with XMM at 4pc (Heard & Warwick 2012)
- emission above 20 keV cannot be explaned by extrapolating known emission components < 10 keV

CHXE origin?

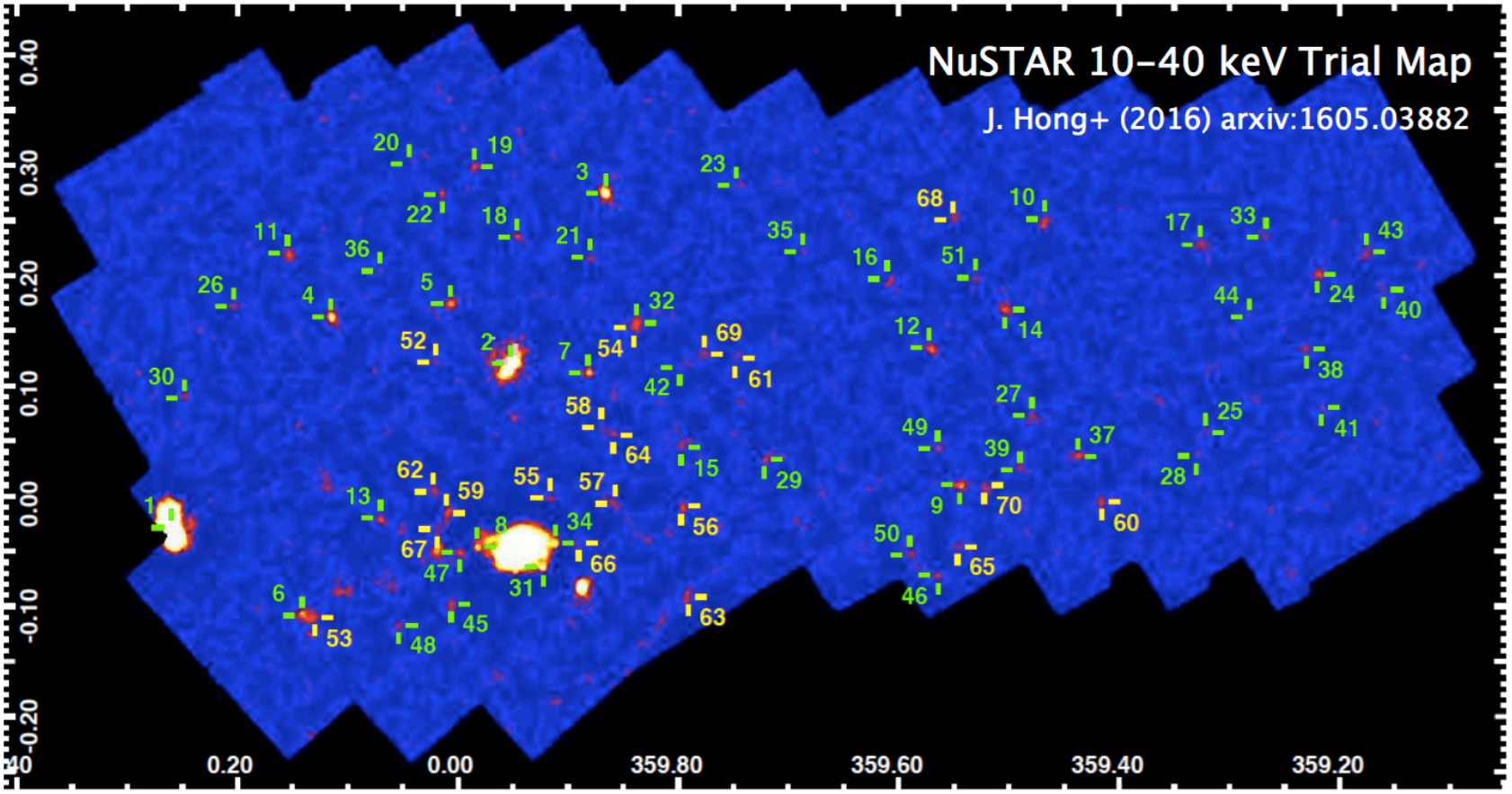
- magnetic filaments, low surface brightness PWNs, or IC can account for only a small fraction of CHXE luminosity and **cannot reproduce spatial distribution**
- low-mass IPs has different latitudinal spatial scale (18' vs 1')
- NS/BH LMXB? Magnetar discovery near Sgr A* predicts large population of NS in GC, however Swift monitoring results do not support that.
- ms Pulsars? Sources identified with Chandra are mostly IPs
- hot IPs with Mwd > 0.9 Msun

NuSTAR Galactic Center Survey Program:



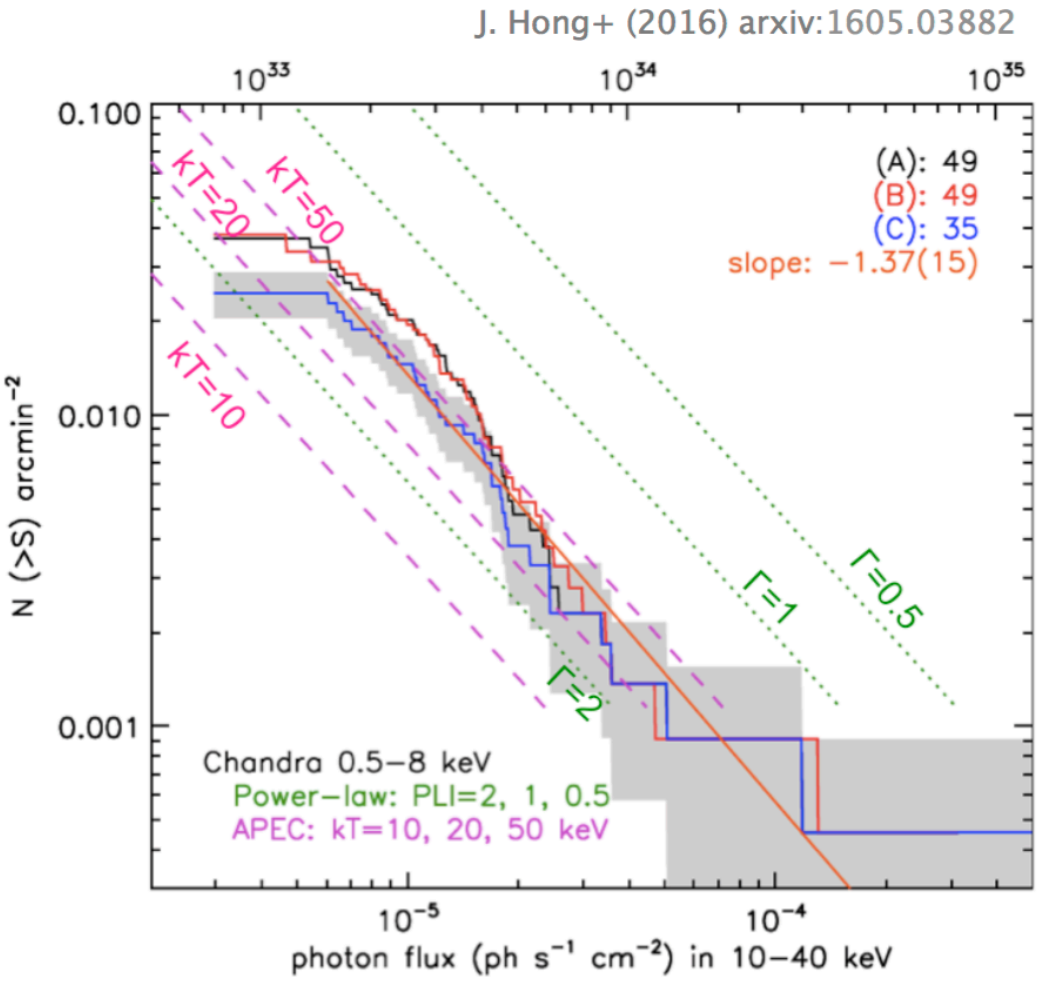
Hard X-ray Point Source Survey

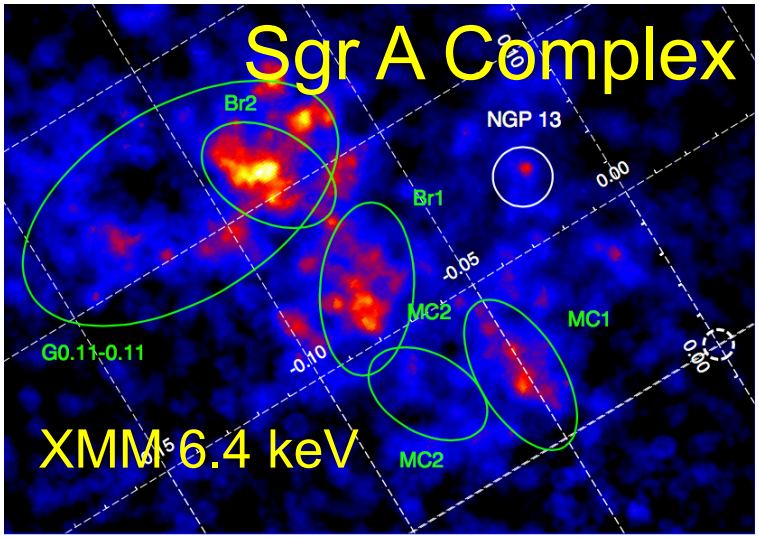
- **70 hard (3-79 keV) X-ray point sources in a 0.6 deg^2 region around Sgr A*** with a total exposure of 1.7 Ms
- **7 sources in the Sgr B2 field** with 300 ks
- Sensitive to ~4x10^{32} erg s^{-1} in 3-10 keV and ~8x10^{32} erg s^{-1} in 10-40 keV

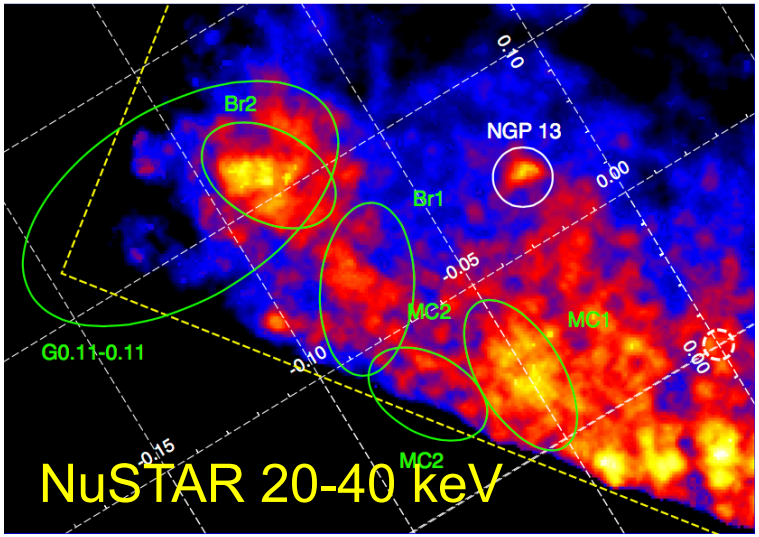


log*N*–log*S* show average spectral parameters

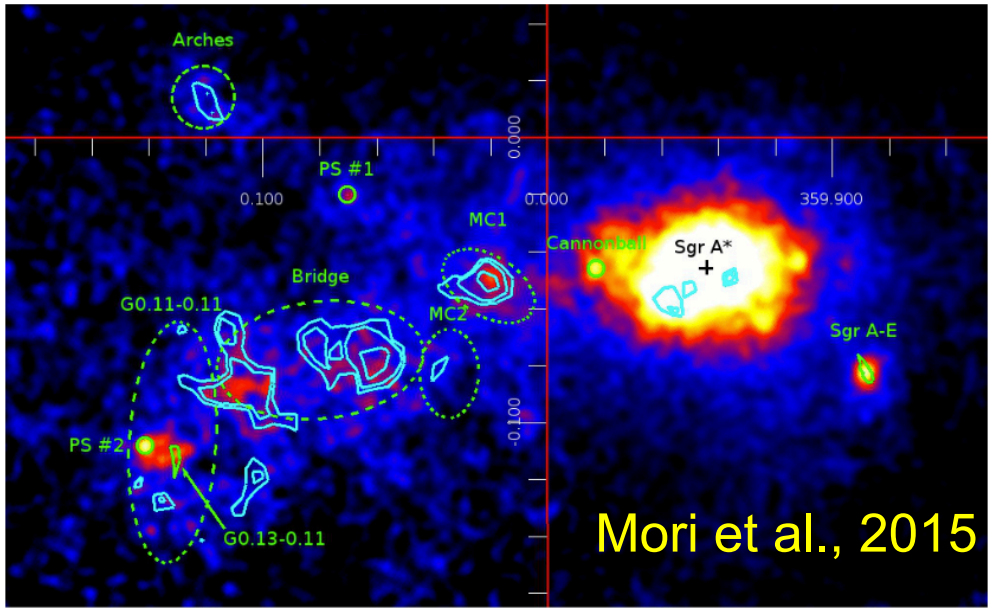
- The NuSTAR (10-40 keV) and Chandra (0.5-8 keV) distributions match if the average spectra are **Γ~1.5-2 or kT ~ 20-50 keV**
- High percentage with Fe lines (60%) and hard spectra **support dominant mCV population**
- Higher plasma temperature than field or Norma regions (Fornasini+ 2016)
- High plasma temperature translates to $\mathbf{M_{WD} > 0.8M_{\odot}}$



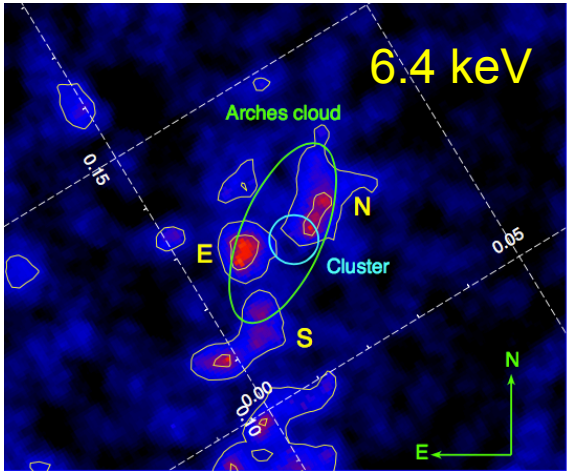


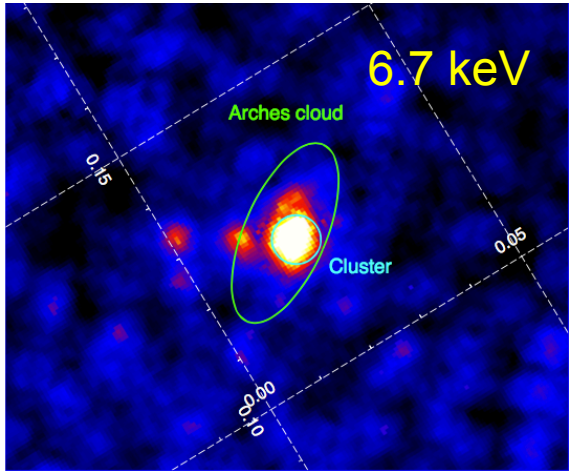


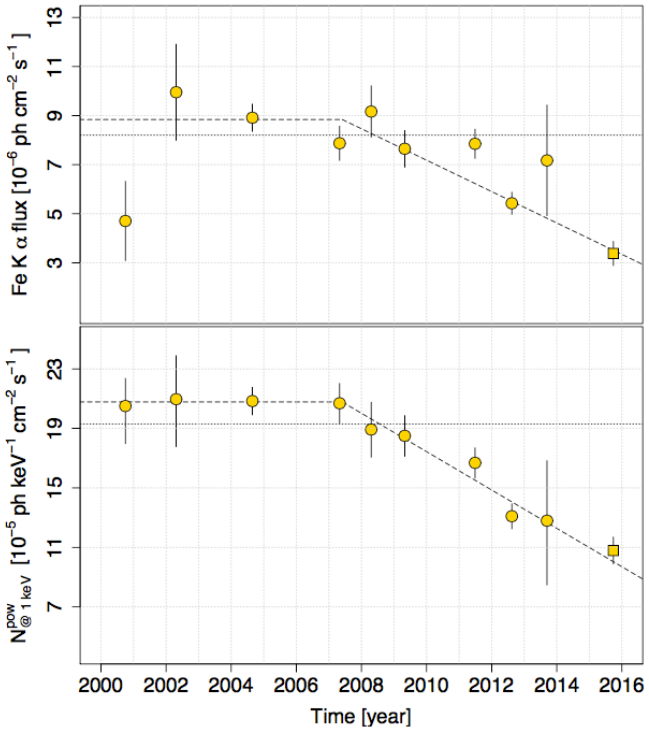
The Arches star cluster molecular cloud

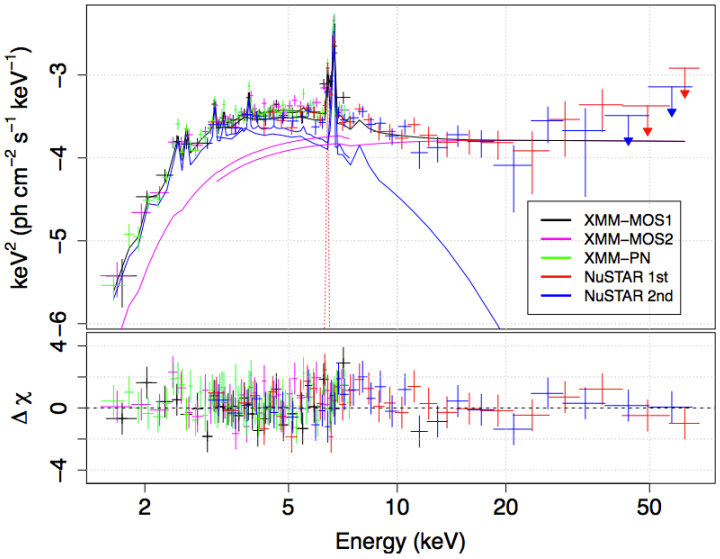


Arches cluster complex



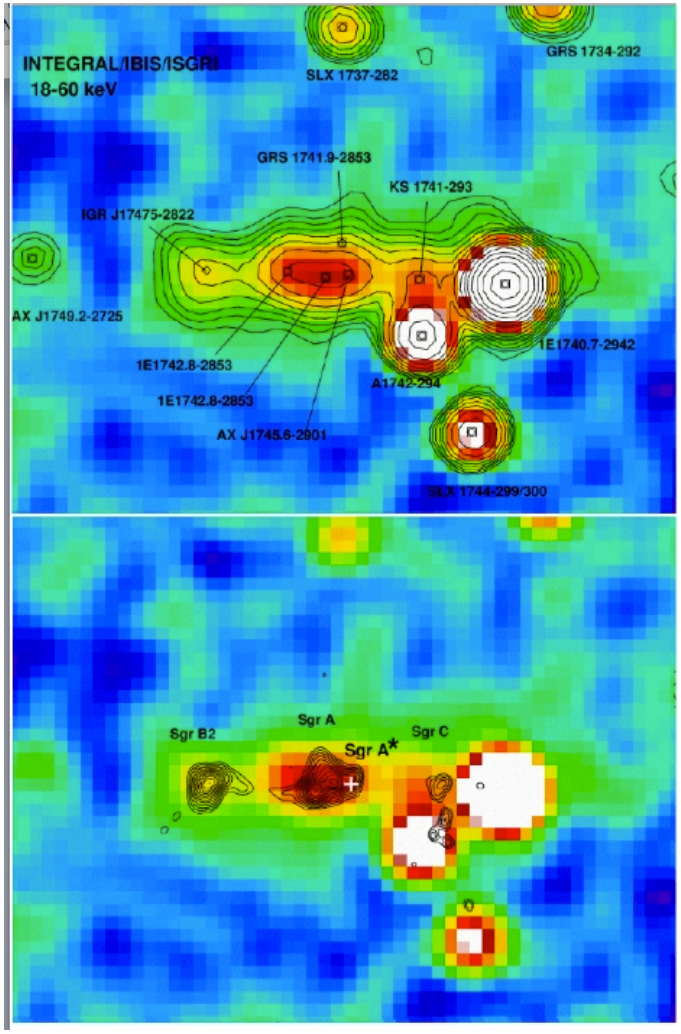




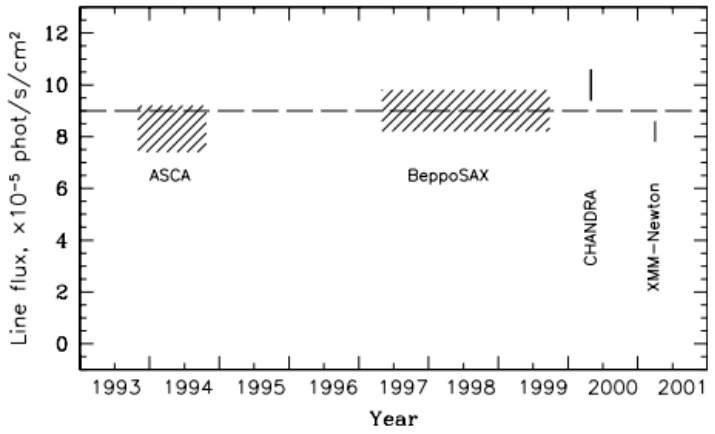


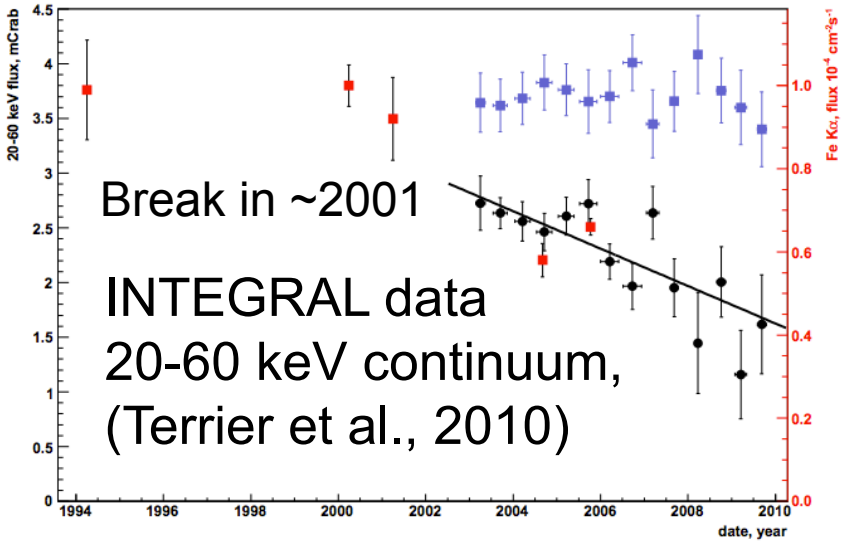
- Declining trend confirmed tau = 8.05 ± 1.28 years (Sgr B2)
- Morphology change
- Power-law Gamma=2
- 6.4 keV EW drop from ~1 keV to 0.5-0.6 keV

Sgr B2 molecular cloud



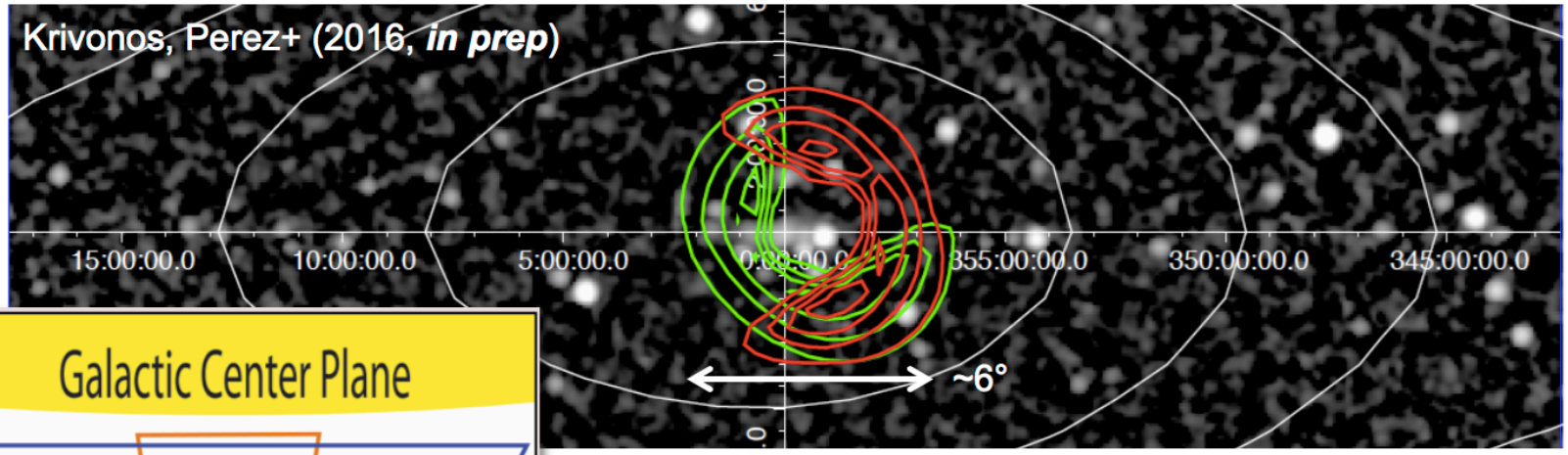
Revnivtsev et al., 2004

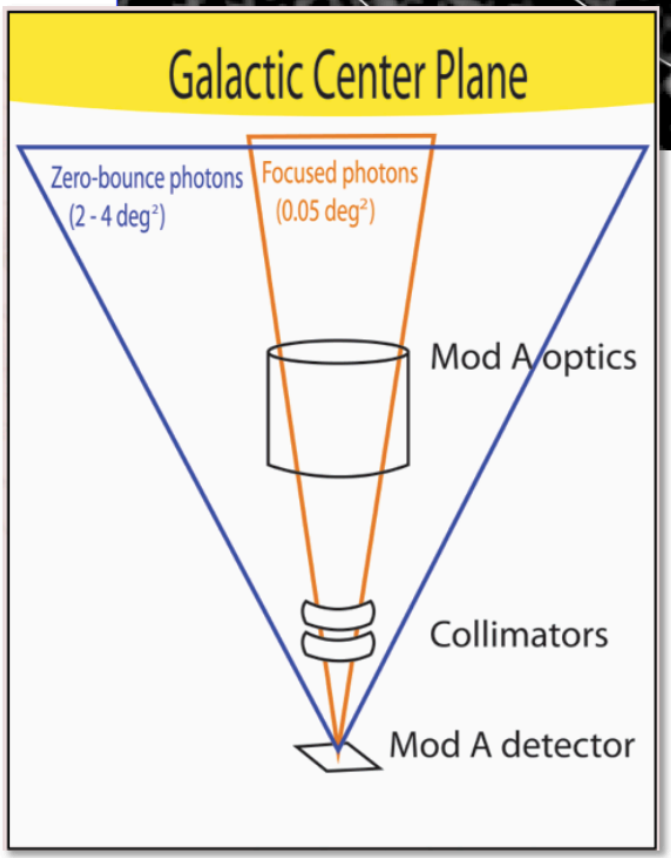




tau = 8.2 ± 1.7 years

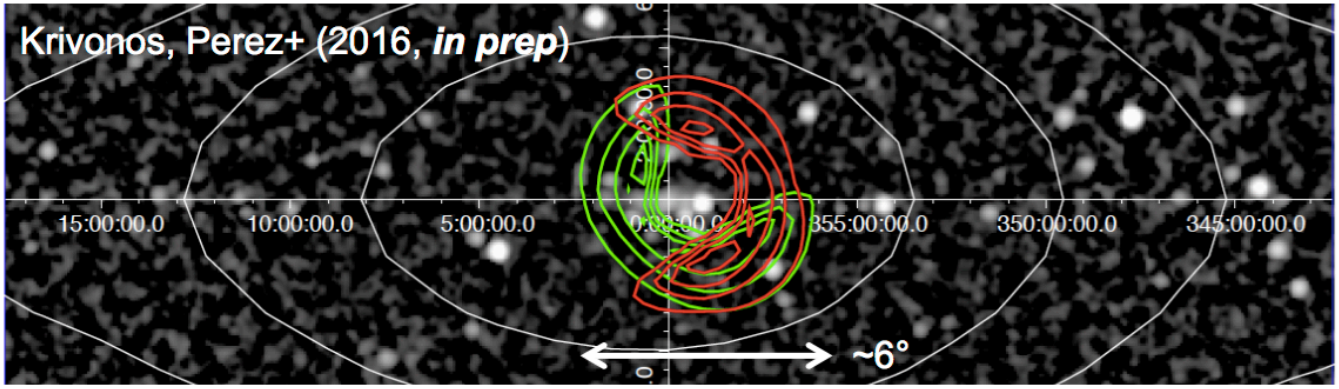
Galactic Ridge X-ray Emission

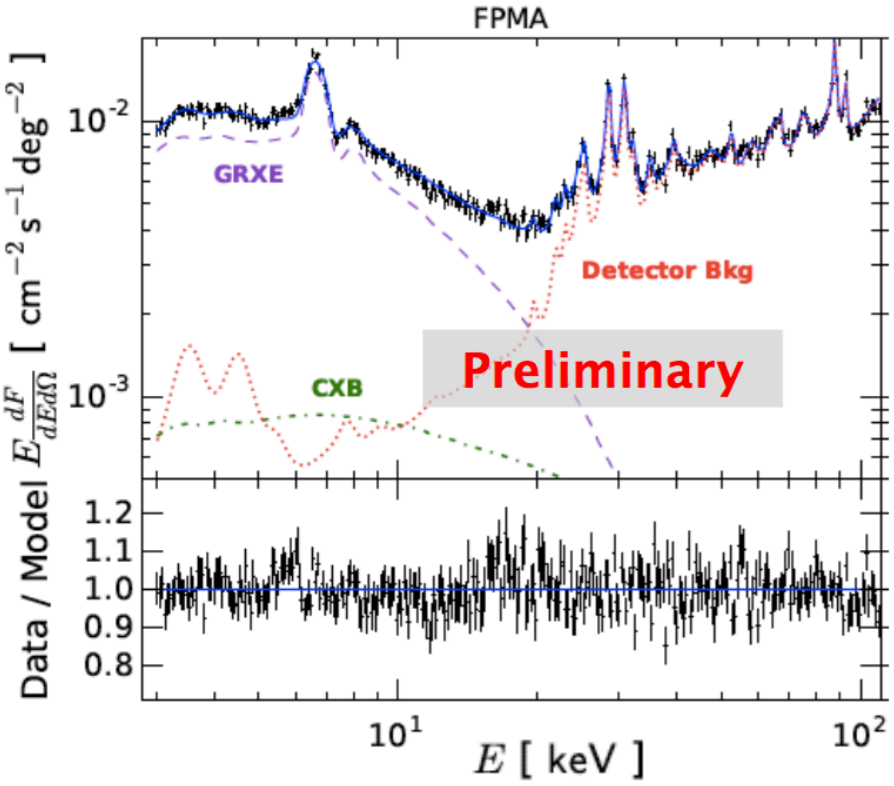




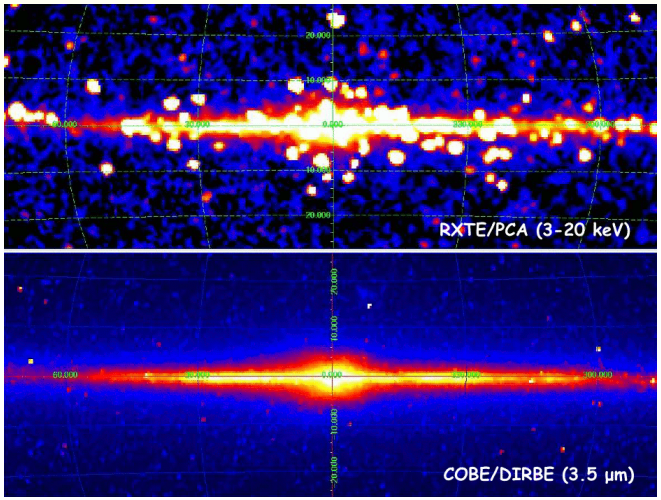
- To survey the diffuse emission over the central ~kpc, need a much wider filed-of-view
- Use ***0-bounce photons***, which for an extended source dominate over the focused photons by over an order of magnitude

Galactic Ridge X-ray Emission

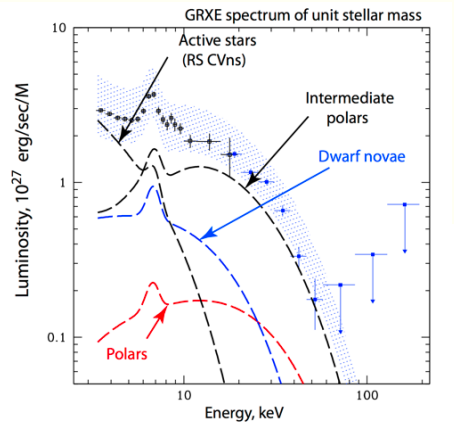


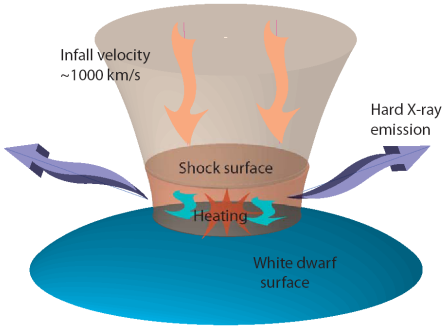


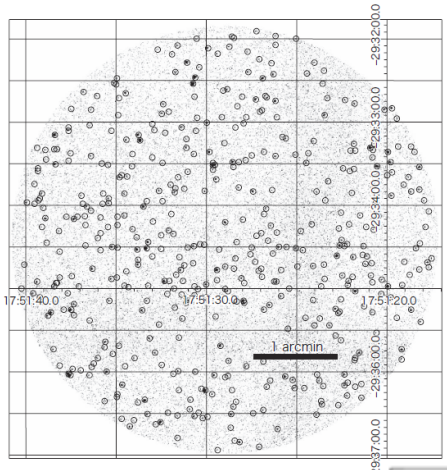
- Spectrum consistent with previous hard X-ray measurements (e.g. Krivonos+ 2007, Türler+ 2010, Yuasa+ 2012)
- If entirely IPs, average $M_{WD} = 0.5M_{O}$
- Contrasts with central parsecs,

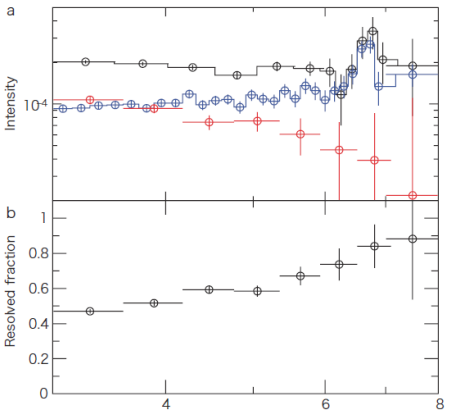

RXTE/PCA (3-20 keV)
COBE/DIRBE (3.5 μm)

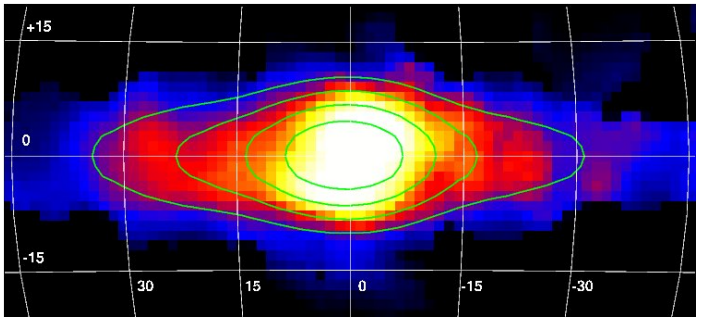

КВАНТ

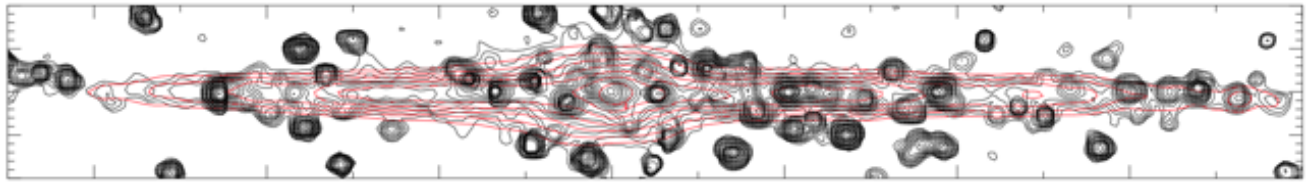

GRXE spectrum of unit stellar mass
Active stars
(RS CVns)
Intermediate
polars
Dwarf novae
Polars
Luminosity, 10^{27} erg/sec/M
Energy, keV
10
1
0.1
10
100

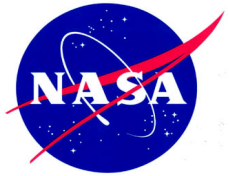

Infall velocity
~1000 km/s
Hard X-ray
emission
Shock surface
Heating
White dwarf
surface


17:51:40.0
17:51:30.0
17:51:20.0
-29:32:00.0
-29:33:00.0
-29:34:00.0
-29:36:00.0
-29:37:00.0
1 arcmin


a
b
Intensity
10^4
Resolved fraction
1
0.8
0.6
0.4
0.2
0
4
6
8


+15
0
-15
30
15
0
-15
-30





NuSTAR

- Спасибо за внимание!